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(54) Suspension system for a vehicle.

(57) A suspension system comprising a pair of FRP spring arms (5), right and left, and a beam assembly (6) connecting the respective free ends (12) of the arms (5). Having a free-end-side portion (12a) vertically bendable, each arm (5) serves as a suspension spring. A fixed end (10) of each spring arm (5) is fixed to a vehicle body (7). The beam assembly (6), which extends in the transverse direction of the vehicle body (7), includes an intermediate beam member (21) of FRP and metallic end beam members (20) fixed individually to two opposite end portions of the intermediate beam member (21). Each end beam member (20) is provided with an axle (11). If the right and left spring arms (5) are subjected to loads of opposite phases at the time of turning, the intermediate beam member (21) is twist-

EP 0 612 931 A1

ed to produce a stabilizer effect.

The present invention relates to a suspension system used in a vehicle such as an automobile.

Steel leaf springs or coil springs have conventionally been used as suspension springs for vehicles. Further, vehicular stabilizers have been used as means for increasing the rolling stiffness of vehicle bodies. Conventional stabilizers are formed independently of suspension springs. A stabilizer comprises a rod-shaped torsion section, which extends in the transverse direction of a vehicle, and a pair of arm sections continuous with the opposite ends of the torsion section. Generally, the torsion section of the stabilizer is supported on the vehicle body by means of brackets with rubber bushes. The arm sections are connected to axle-side components, such as a lower arm, by means of stabilizer links.

The suspension coil springs, which are disposed vertically so that their axes extend in the vertical direction, have a great upward projection. Therefore, spaces for storing the upper portions of the suspension springs are needed in the trunk room or engine room. This results in a narrow interior space of the vehicle. Since the suspension springs and the stabilizer must be mounted separately, moreover, the whole suspension system requires a complicated structure and use of many components. Furthermore, it is hard to secure mounting spaces for the suspension springs and the stabilizer.

A suspension system disclosed in Published Unexamined Japanese Utility Model Application No. 62-131905 comprises a pair of cantilever leaf springs, and a steel axle connecting the respective free ends of the springs. This axle is a substantially rigid body. In this conventional example, a stabilizer is required independently of the leaf springs. In this case, moreover, the axle is a long steel member extended between right and left wheels, and therefore, is inevitably heavy in weight.

A suspension system with the features of the preamble of claim 1 is described in "Automotive Engineer", 14 (1989), No.3, Bury St. Edmunds, GB. This known suspension system for a vehicle comprises two hot press moulded spring arms incorporating continuous glass reinforcement constructed by filament winding and resin transfer moulding techniques and each of said arms is to be connected at a fixed-end-side portion to the vehicle body and at a free-end-side portion to respective ends of a beam assembly extending transvers to the vehicle body.

It is the object of the present invention to provide a suspension system for a vehicle, whose upward projection is smaller than that of conventional suspension systems using suspension coil springs, and which can serve also as a stabilizer, and is light in weight.

According to the invention there is provided a suspension system for a vehicle connecting a vehicle body and axle means, comprising a left and a right spring arm both made of FRP, said arms being vertically bendable and each arm having a fixed end to be fixed to the vehicle body and a free-end-side portion extending toward the axle means, a beam assembly extending in the transverse direction of the vehicle body and having connecting portions connected to the respective free-end-side portions of the pair of spring arms, and connecting means for connecting the spring arms to the beam assembly, characterized in that said beam assembly including a pair of metallic end beam members which define said connecting portions, respectively, connected to the spring arms, an intermediate beam member of FRP having two opposite end portions fixed individually to the end beam members, and a pair of U-shaped connecting fixtures fixed individually to the end beam members and each having a pair of clamp pieces holding each corresponding end portion of the intermediate beam member in between, and means for fixing the clamp pieces of the connecting fixtures to the intermediate beam member.

Each end beam member can be formed of a hollow member, such as a round or rectangular pipe.

In a vehicle provided with the suspension system constructed in this manner, its sprung weight is elastically supported by means of the right and left spring arms. Vertical displacements of wheels caused when the vehicle run on a rough road surface are absorbed by the arms which bend vertically. When the vehicle curves or turns to change its course, the vehicle body is subjected to a transverse acceleration, so that its inside with respect to the turn is lifted, while the outside sinks. In this case, therefore, the two spring arms bend in opposite directions, so that the intermediate beam member is twisted. A resulting reaction force serves to keep the vehicle body horizontal, as in the case of a conventional stabilizer.

Thus, the beam assembly functions both as axle means and as a stabilizer. The Young's modulus of the intermediate beam member, made of FRP, is much lower than that of a steel beam, so that it can undergo a deflection large enough for a stabilizer effect.

Since the suspension system of the present invention is smaller in vertical size than conventional suspension systems using suspension coil springs, the vehicle can enjoy a wide interior space. Since the combination of the spring arms and the beam assembly functions as a stabilizer, moreover, the whole suspension system requires use of fewer components than the conventional systems, and its structure is simpler. Furthermore,

the spring arms and the intermediate beam member, which are formed of FRP, never rust, and are light in weight.

This invention can be more fully understood from the following detailed description when taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a perspective view showing the rear portion of an automobile provided with a suspension system according to an embodiment of the present invention;

Fig. 2 is a partial perspective view of the suspension system shown in Fig. 1;

Fig. 3 is a partial front view of the suspension system shown in Fig. 1;

Fig. 4 is a sectional view taken along line V-V of Fig. 3;

Fig. 5 is a partial perspective view of a suspension system according to another embodiment of the invention;

Fig. 6 is a partial perspective view of a suspension system according to the embodiment of the invention; and

Fig. 7 is an exploded perspective view of the suspension system shown in Fig. 7.

An embodiment of the present invention will now be described with reference to the drawings, which show a rear suspension system for an automobile. The automobile 1 shown in Fig. 1 is provided with a pair of rear wheels 2 and 3. The wheels 2 and 3 are supported on a vehicle body 7 by means of the suspension system 4.

The suspension system 4 comprises a left and right cantilever spring arms 5 both made of FRP, and a beam assembly 6 extending in the transverse direction of the vehicle body 7 (shown only partially). Each spring arm 5 is in the form of a leaf composed of a resin matrix 8 and a large number of continuous reinforcing fibers 9 extending in the longitudinal direction of the arm. The fibers 9 are contained throughout the cross section of each arm 5. Each arm 5 has a fixed end 10 fixed to the vehicle body 7 and a free end 12 situated beside an axle 11. The arms 5 extend in the longitudinal direction of the body 7.

The spring arms 5 may be arranged parallel to a center line which extends in the longitudinal direction of the vehicle body 7, as viewed from above, or be arranged in the shape of a V such that the distances between their respective fixed ends 10 and between their respective free ends 12 vary in the longitudinal direction of the vehicle body. As shown in Fig. 3, each arm 5 has a rectangular profile (in the direction perpendicular to the longitudinal direction of the arm) which is long from side to side, that is, whose width B1 is greater than its thickness T1.

The fixed end 10 of each spring arm 5 is fixed to the vehicle body 7 by means of fixing members 15 and bolts (not shown) or the like. Thus, each arm 5 functions as a cantilever spring such that its free-end-side portion 12a can elastically bend in the vertical direction. Each spring arm 5 may be tapered so that its thickness decreases from the fixed end 10 toward the free end 12 without changing its width, or that its width and thickness increase and decrease, respectively, from the fixed end 10 toward the free end 12.

The beam assembly 6 connects the respective free ends 12 of the spring arms 5. It is composed of a pair of end beam members 20, each formed of a round steel pipe fixed to its corresponding arm 5, and an intermediate beam member 21 of FRP situated between the end beam members 20. The intermediate beam member 21, like each spring arm 5, is composed of a resin matrix 22 and a large number of continuous reinforcing fibers 23 extending in the longitudinal direction of the member 21. The fibers 23 are contained throughout the cross section of the beam member 21.

As shown in Fig. 4, the intermediate beam member 21 has a vertically elongated rectangular profile whose thickness (height) T2 is greater than its width B2 in the longitudinal direction of the vehicle body. The overall length of the beam assembly 6 is 1,140 mm, for example. The intermediate beam member 21 is 400 mm long, 66 mm thick (T2), and 22 mm wide (B2), for example. The glass fiber content of the beam member 21 with respect to the longitudinal direction thereof is 72.5% by weight. The torsional rigidity of the intermediate beam member 21 is 1.025×10^5 (kgf•mm/degree), for example. It is to be desired that the profile of the member 21, which may be substantially square, should be rectangular.

Each end beam member 20 and the intermediate beam member 21 are rigidly connected to each other by means of a connecting fixture 100. In figures 1 to 3 and 5 the connecting fixture is shown as a box 100 for simplification. According to the embodiment of the invention as shown in Figs. 6 and 7, the connecting fixture 100, which is made of metal such as steel, is bent substantially U-shaped, thus forming a pair of clamp pieces 101 and 102. An end portion 21a of the intermediate beam member 21 is inserted between the pieces 101 and 102, and is clamped in the thickness direction by means of a suitable number of bolts 103 and nuts 104. The bolts 103 are passed individually through holes 107 and 108 in lugs 105 and 106 which are formed on the clamp pieces 101 and 102, respectively.

The connecting fixture 100 is fixed to the end beam member 20 by welding. More specifically, a pair of extension portions 110 and 111, which are provided at the end of the beam member 20, are

welded to the fixture 100 at welding areas 112 in a manner such that the fixture 100 is held between the portions 110 and 111. A bolt 103a is passed through holes 109a in the clamp pieces 101 and 102, holes 109b in the extension portions 110 and 111 and a hole 109c in the intermediate beam member 21, and a nut 104a is screwed on the bolt 103a.

As shown in Figs. 2 and 3, the end beam member 20 is fixed to the free-end-side portion 12a of the spring arm 5 by means of an U-bolt 65, a nut 66, washer plates 67 and 68, etc. Buffer spacers 69a and 69b are interposed between the portion 12a and the washer plates 67 and 68.

The sprung weight of the automobile 1, provided with the suspension system 4 constructed in this manner, is elastically supported by means of the spring arms 5. The arms 5 function as suspension springs. While the automobile 1 is running, the up-and-down motions of the wheels 2 and 3, caused by the roughness of the road surface, are absorbed by the respective free-end-side portions 12a of the spring arms 5 which bend vertically. If the left and right spring arms 5 are subjected to loads of opposite phases due to a centrifugal force produced at the time of a change of course or curving, the arms 5 bend in opposite directions so that the intermediate beam member 21 is twisted. If the beam member 21 is twisted in this manner, a reaction force around the member 21 is produced depending on the size of the twist. Accordingly, a force to twist one end side of the beam assembly 6 is transmitted to the spring arm 5 on the other end side of the assembly 6. This twisting force acts on the arm 5 as a force to keep the vehicle body horizontal. Thus, the suspension system 4 fulfills its function as a stabilizer. Since the Young's modulus of the intermediate beam member 21, made of FRP, is lower enough than that of a structural element made of steel, a sufficient deflection can be ensured for a stabilizer effect.

The spring arms 5 function as structural elements for supporting the load acting in the longitudinal direction of the vehicle body. The intermediate beam member 21 serves as a structural element for supporting the load acting in the transverse direction of the vehicle body. Thus, in the suspension system 4 according to the present embodiment, use of conventional rigid auxiliary members, such as lateral rods, tension rods, etc., can be reduced or omitted.

Since the upward projection of the suspension system 4 of this embodiment is smaller than that of conventional suspension systems using suspension coil springs, so that the trunk space and the like can be widened. Since the FRP is used as the material for the spring arms 5 and the intermediate beam member 21, moreover, the whole system 4 is light in weight. More specifically, the weight ratio between a conventional strut-type suspension system using suspension coil springs and the suspension system 4 of the present embodiment is 100:69. The weight ratio for the case in which a rigid body formed of a round steel pipe similar to a conventional axle housing is used in place of the beam assembly 6 of the present embodiment is 100:83. Further, the weight ratio for the case in which a steel beam having a vertically elongated rectangular profile and vertical rigidity equal to that of a round steel pipe is used is 100:75. In any of these comparative examples, the weight of the system is heavier than the suspension system 4 of the present embodiment.

In another embodiment of the present invention shown in Fig. 5, a spring arm 5 and a beam assembly 6 is connected to each other by means of a connecting mechanism 70. The beam assembly 6 is constructed in the same manner as in the first embodiment described above. The connecting mechanism 70 is provided with a metal frame 71, which includes a bottom wall 72 put on the arm 5, a pair of side walls 73 and 74 rising on either side of the bottom wall 72, and a top wall 75 facing the bottom wall 72. The side walls 73 and 74 are formed having holes 76 and 77, respectively, through which an end beam member 20 is passed. Each side wall is shaped so that its upper edge declines from one end (having the hole 76 or 77) toward the other end 78 of the frame 71, as viewed sideways. Thus, the top wall 75 also declines from the one end side toward the other end 78. The spring arm 5 and the frame 71 are firmly fixed to each other by means of a wedge member 80 which is interposed between the top wall 75 and the arm 5.

Claims

1. A suspension system for a vehicle connecting a vehicle body (7) and axle means (11), comprising

   a left and a right spring arm (5) both made of FRP, said arms (5) being vertically bendable and each arm (5) having a fixed end (10) to be fixed to the vehicle body (7) and a free-end-side portion (12a) extending toward the axle means (11),

   a beam assembly (6) extending in the transverse direction of the vehicle body (7) and having connecting portions connected to the respective free-end-side portions (12a) of the pair of spring arms (5); and

   connecting means (65, 66) for connecting the spring arms (5) to the beam assembly (6);

   characterized in that said beam assembly (6) including

a pair of metallic end beam members (20) which define said connecting portions, respectively, connected to the spring arms (5),

an intermediate beam member (21) of FRP having two opposite end portions (21a) fixed individually to the end beam members (20), and

a pair of U-shaped connecting fixtures (100) fixed individually to the end beam members (20) and each having a pair of clamp pieces (101, 102) holding each corresponding end portion (21a) of the intermediate beam member (21) in between, and means (103, 104) for fixing the clamp pieces (101, 102) of the connecting fixtures (100) to the intermediate beam member (21).

2. The suspension system according to claim 1, characterized in that each said FRP spring arm (5) includes a resin matrix (8) and a large number of unidirectional continuous fibers (9) extending along the longitudinal direction of the arm (5).

3. The suspension system according to claim 1, characterized in that said intermediate beam member (21) includes a resin matrix (22) and a large number of unidirectional continuous fibers (23) extending along the longitudinal direction of the intermediate beam member (21).

4. The suspension system according to claim 1, characterized in that the profile of said intermediate beam member (21) is rectangular.

5. The suspension system according to claim 1, characterized in that each said end beam member (20) is formed of a cylindrical metal pipe.

6. The suspension system according to claim 1, characterized in that said connecting means (65, 66) includes U-bolts (65) and nuts (66).

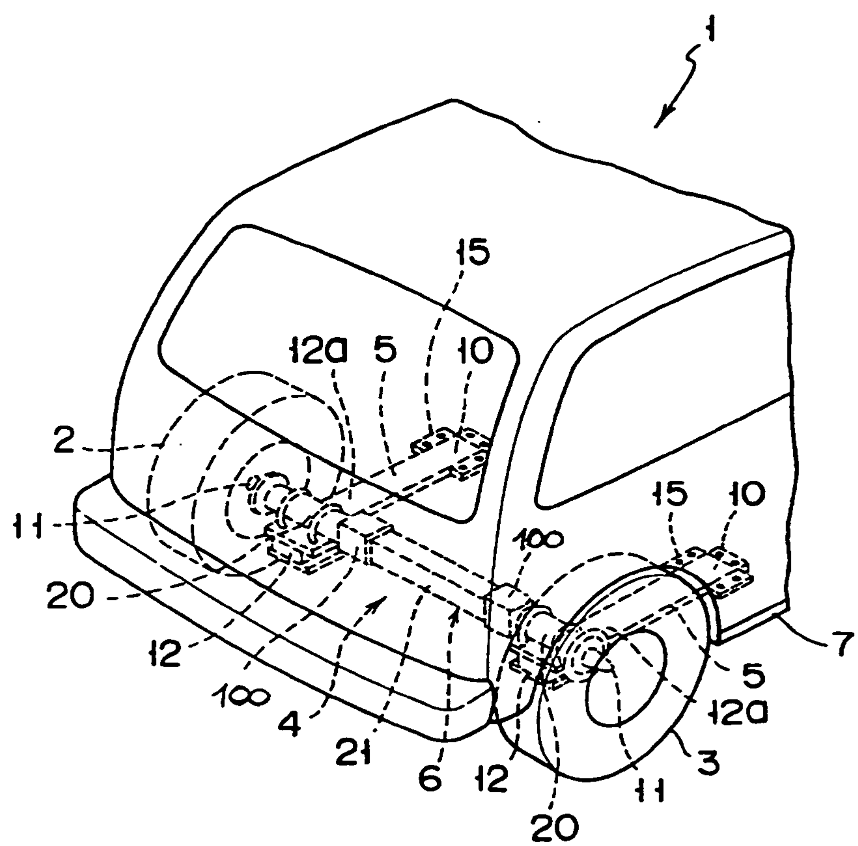
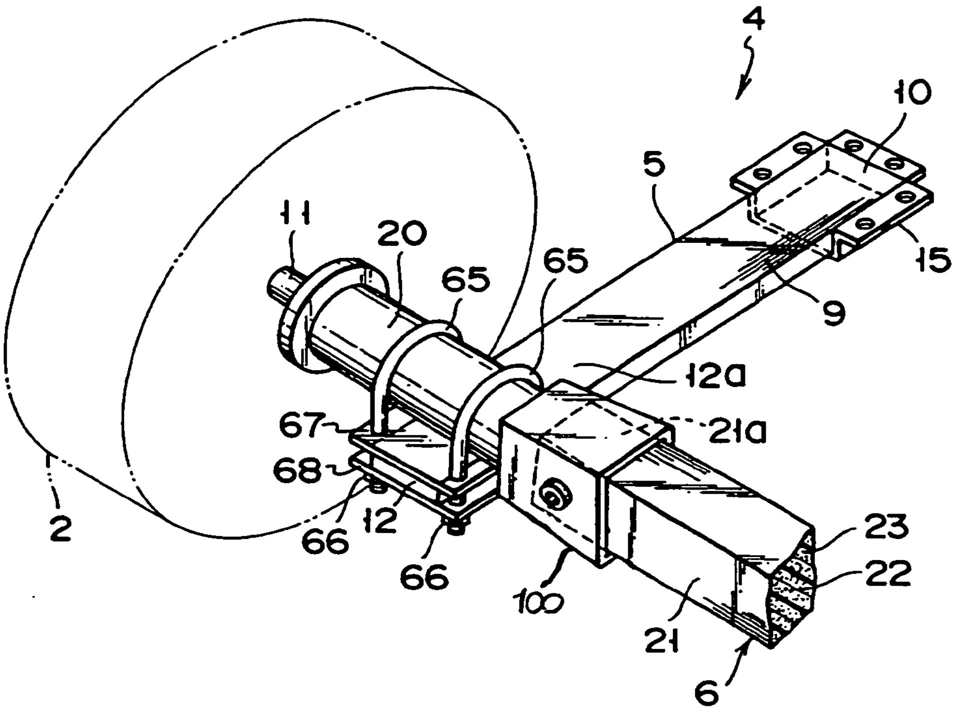
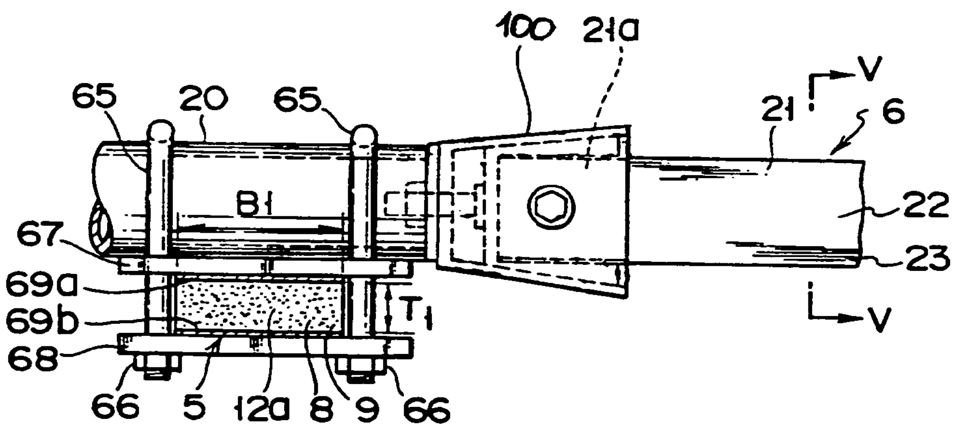


FIG. 1



4
10
5
11
20
65
65
15
9
12a
67
21a
68
2
66
12
23
66
22
100
21
6

F I G. 2



100
21a
65
20
65
21
V
6
B1
22
67
23
69a
69b
T1
V
68
66
5
12a
8
9
66

F I G. 3

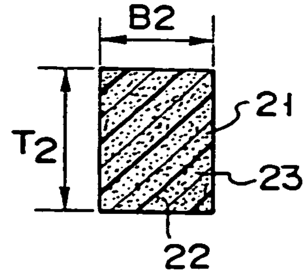
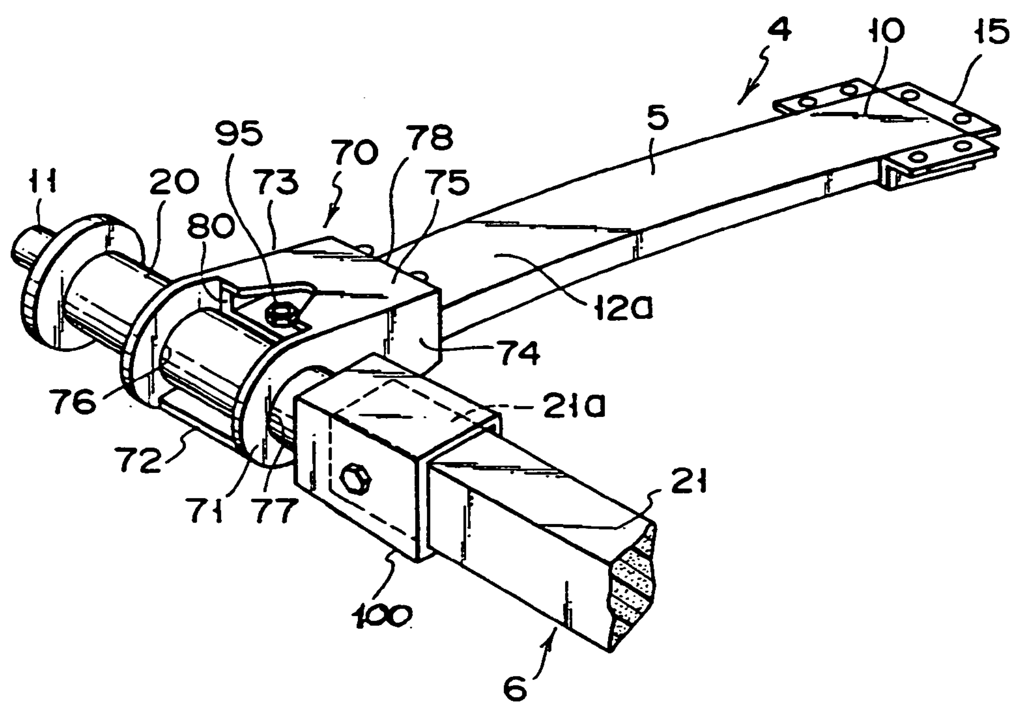

B2
T2
21
23
22

FIG. 4


4
10
15
5
95
70
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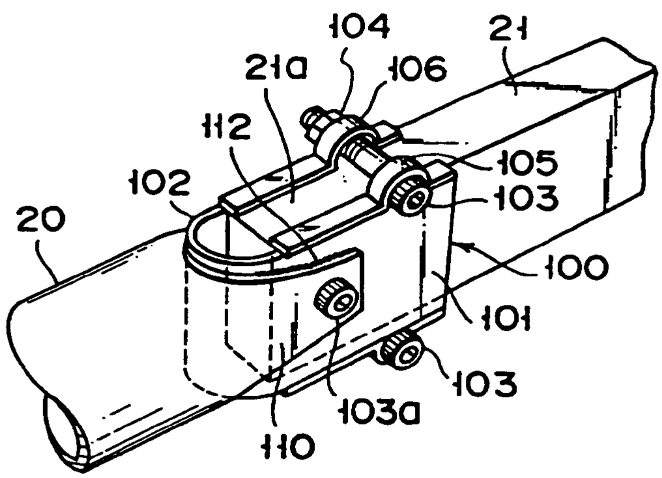
75
80
12a
74
76
21a
72
71
77
21
100
6

FIG. 5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21a
106
112
105
102
103
20
100
101
103
103a
110

FIG. 6

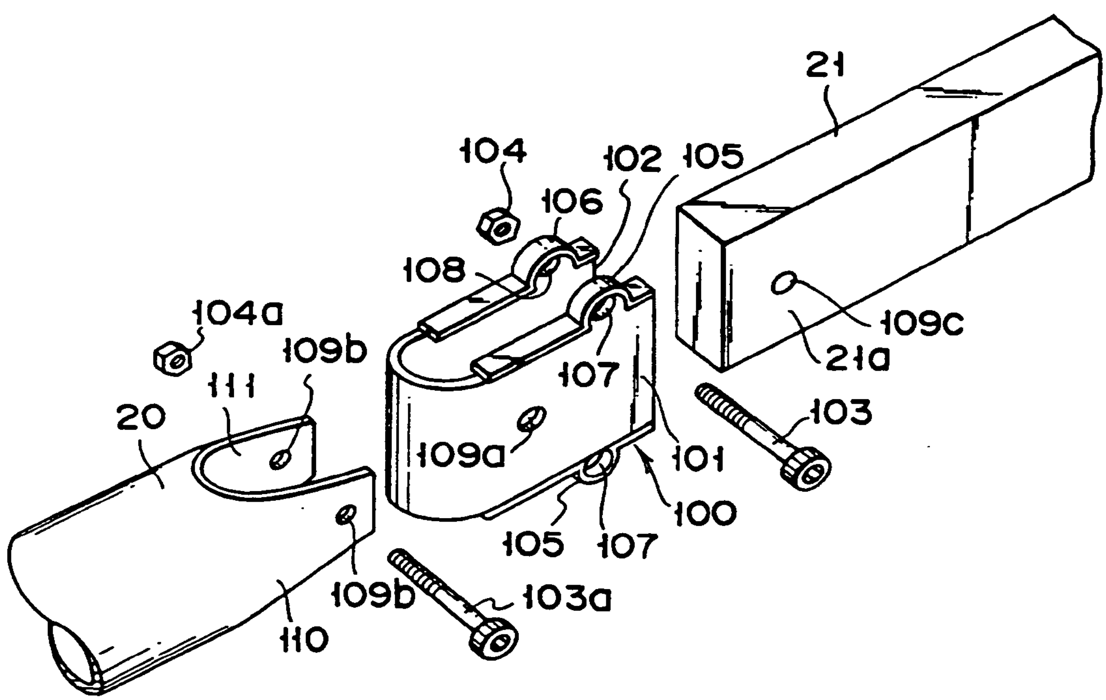
21
104
102
105
106
108
104a
109c
109b
21a
111
107
103
20
109a
101
100
105
107
109b
103a
110

FIG. 7

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 94 10 4536

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.5)
A	AUTOMOTIVE ENGINEER, vol.14, no.3, June 1989, BURY ST.EDMUNDS, GB page 8 * column 4 *	1-4	F16F1/36 B60G21/055 F16C3/02 B60G11/04 B60G9/00 B60B35/00
A	AUTOMOTIVE ENGINEER, vol.8, no.3, June 1983, BURY ST.EDMUNDS, GB pages 40 - 43 'CFRP-for-steel substitution in a car rear axle' * page 43; figure 3 *	1-4	
A	EP-A-0 243 191 (SECR. OF STATE FOR TRADE AND INDUSTRY UK) * the whole document *	1-5	
A	EP-A-0 202 964 (REGIE NATIONALE DES USINES RENAULT) * the whole document *	1,2	TECHNICAL FIELDS SEARCHED (Int.Cl.5)
A	GB-A-2 145 797 (UKAEA) * the whole document *	1-4	F16F B60G B60B F16C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	29 June 1994	Pemberton, P

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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